

**On the Terrestrial Planarians from the Islands
of Mauritius and Rodrigues; with a Note
upon the Canal connecting the Female Genital
Organ with the Intestine.**

By

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With Plate 4 and 6 Text-figures.

Few terrestrial planarians are as yet known to occur in the islands remote from continental land in the Indian Ocean. Such are *Pelmatoplanea mahéensis* von Graff and *P. braueri* von Graff (12, 20) from the Seychelles, *Placocephalus isabellinus* Geba (11) from Mauritius, *Geoplana whartoni* Gulliver (1) from Rodrigues, and *Rhynchodemus ceylonicus* von Graff (17) from Male Atoll.

The material serving as a basis of the present report was collected by Mr. H. P. Thomasset in October, 1918, in the island of Mauritius, and by Mr. H. J. Snell in November and December of the same year in the island of Rodrigues. The specimens were sent to Professor J. S. Gardiner, who kindly turned them over to me for examination.

In this communication it may not be out of place to add a brief account of *G. whartoni* Gulliver, known as occurring in the Rodrigues Island. I am much indebted to the Director of the British Museum of Natural History for the privilege of studying this species.

The following is a list of the species dealt with in the present paper :

Geoplana whartoni Gulliver ;

Placocephalus isabellinus Geba :

Rhynchodemus ceylonicus von Graff ·

Amblyplana trifuscolineata, n. sp.

The planarian fauna of the islands mentioned above is regarded by von Graff to be derived from that of the Aethiopian region, whilst the species referable to *Rh. ceylonicus* has been clearly brought from Ceylon through the agency of man.

Before proceeding further, it gives me great pleasure to express my deep indebtedness to Professor J. S. Gardiner for his suggestions and kind assistance throughout this work in his laboratory. I deem it my duty to mention my indebtedness to Dr. Sir A. E. Shipley for his kind help in many respects. My best thanks are also due to Dr. H. A. Baylis for providing me with opportunities and accommodation for the examination of the Museum material.

Geoplana whartoni Gulliver.

(Text-fig. 1.)

Geoplana whartoni Gulliver (1), pp. 561, 562, Pl. iv, fig. 1.—
von Graff (12), p. 347, Pl. iv, figs. 12-14, Pl. xxvi, fig. 4.

This species, according to Gulliver's statement, occurs in situations similar to those in which the nemertean, *Tetradostemma rodericanus*, lives, and, indeed, is often found together with it. He collected some specimens on rotten wood.

External Characters.—The body is elongate, slender, and for the most part nearly uniformly broad, though it tapers off considerably in front. The sole on the mid-ventral surface is slender, and corresponds to about one-ninth the width of the body. Well-grown specimens in the preserved state measure 15-20 mm. long by about 2 mm. broad.

The ground colour of the dorsal surface is cream, with three dark-brown stripes which run almost throughout the whole length of the body, and anteriorly merge into the general colour of the head-end, without revealing a dark tip. The ventral surface is a somewhat paler shade of the same colour as the dorsal, without any markings.

The numerous eye-spots are arranged in a single row round the anterior tip, and continue sparsely for some distance down the sides.

The mouth-opening, which leads into the peripharyngeal chamber, is placed somewhat behind the centre of the body, in the mid-ventral line.

The common genital opening lies nearer to the posterior end of the body than to the mouth-opening.

Epidermis and Body-glands.—The following account is based on a single specimen received from the British Museum. The epidermis consists of a layer of columnar cells, which are about equally high on the dorsal and ventral surface, and possess cilia, which, however, are confined to the latter surface. It contains spindle-shaped rhabdites on the dorsal surface only, where they are found in enormous quantities, evidently situated between the epidermal cells. Immediately beneath the superficial muscular system there occur such rhabdites as are still contained in their mother-cells. These are scattered in sparse numbers in the parenchyma. There are enormous quantities of slime glands, deeply situated in the parenchyma, opening not only to the exterior all over the surface of the sole, but in a narrow zone of the ventral surface along and just within the margin of the body.

Muscular System.—The musculature of the body presents no noteworthy features, consisting, as it does, of two systems, superficial and deep, which are rather more strongly developed on the ventral than on the dorsal side, doubtless in relation to the movements. Dorso-ventral fibres occur also in the usual manner.

Digestive System.—The mouth-opening is situated somewhat behind the middle of the body and at nearly the centre of the peripharyngeal cavity, with the pharynx horizontally disposed. The pharynx is a cylindrical tube, terminating conically at the free end. Embedded in the parenchyma in front of the pharynx-insertion are numerous salivary glands, which continue their way to the free end of the pharynx.

All the three main trunks of the intestine give off numerous lateral branches, which are sometimes bifurcated and sometimes 'multifurcated'. The epithelium consists, as usual, of a single

layer of high cylindrical cells. So far as I have observed, special glands are altogether absent in the lining epithelium.

Nervous System.—The exact arrangement of the nervous system could not be ascertained, but it seemed to be quite similar to that previously observed in several forms of this genus. Each half of the bilobed brain-mass is continuous posteriorly with one of the longitudinal nerve cords, which proceed, running nearly parallel to each other, to the hind end of the body, and are connected together by transverse commissures. Lateral nerves are given off from the cords towards the nerve plexus, which lies directly beneath the superficial muscular system.

The eye consists simply of a small pigment cup, partly filled with a peculiar cellular substance, whose true nature could not be ascertained from any of the sections available.

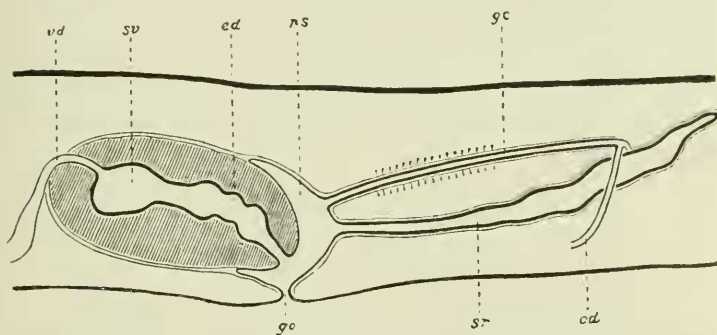
Reproductive Organs.—The genital organs are in accordance with those described by von Graff. The common genital opening leads directly into the penis-sheath, which receives from behind the openings of the seminal receptacle (uterus) and the glandular canal. The cavity is lined with a single epithelium resting upon a fine basement membrane, beneath which are found circular and longitudinal muscular layers.

Male Organs.—The numerous testes occur close together in the ventral parts of the body, arranged in two longitudinal lateral zones which extend from behind the ovaries to nearly the region of the copulatory organs. Each testis is, as usual, made up of sperm-mother-cells and spermatozoa in all stages of development, surrounded by the tunica propria. Probably they are all connected by testicular ductules, but these could not be definitely made out. Not far in front of the penis the vasa deferentia rise obliquely upwards to enter the penis-bulb separately at the upper lateral sides and finally open into the lumen of the penis or the seminal vesicle. The vas deferens, which is filled with spermatozoa, has a wall consisting of an epithelium and an outer layer of circular muscular fibres.

In the penis there can be distinguished the conical intromittent part, lying nearly horizontally in the penis-sheath, and the

bulbous part of muscular nature, which contains a cavity of somewhat irregular contour, the seminal vesicle. The vesicle gives rise to the moderately wide ejaculatory duct which opens at the tip of the penis. The muscular fibres of which the penis is composed are arranged in two principal sets, circular and longitudinal, the fibres of the two sets occurring intermingled with one another. Embedded in the parenchyma of the penis are numerous glands, the ducts of which open into its lumen lined by a layer of small columnar cells.

TEXT-FIG. 1.



Diagrammatic representation figure of the sexual organs of *Geoplana whartoni* Gulliver. *ed.*=ejaculatory duct. *gc.*=glandular canal. *go.*=genital opening. *od.*=oviduct. *ps.*=penis-sheath. *sr.*=seminal receptacle. *sv.*=seminal vesicle. *vd.*=vas deferens.

Female Organs.—The paired ovary occupies a ventral position somewhat behind the brain. It is a nearly oval body made up of egg-cells in several stages of development. From the lateral aspect of the ovary the oviduct starts as an ampullaceous passage, which soon takes the character of a narrow duct and proceeds backwards just outside the longitudinal nerve cords, receiving the vitelline glands at numerous points. The vitelline glands are represented by branching cellular masses, which are extensively distributed in the interstices between the gut diverticulæ. The mode of the connexion of the glands with the oviduct is effected by means of the short branches of the

latter. Far behind the genital opening the oviduct rises obliquely upwards, to unite with its fellow of the opposite side into a single common duct, the glandular canal, which opens into the penis-sheath from behind, after receiving numerous glands. The duct exhibits a distinct lumen throughout the entire length. Its direct wall is lined by a ciliated epithelium, outside which is a layer of circular muscular fibres.

At a short distance below the opening of the glandular canal the penis-sheath gives rise to a narrow passage, which pursues a somewhat tortuous course obliquely backwards and upwards, becoming gradually wider at the same time. Beyond the junction point of the oviducts it extends further backwards. This organ, which doubtless represents the seminal receptacle, has a wall consisting of a non-ciliated epithelium and a fine muscular coating; in the cavity are found enormous quantities of spermatozoa.

Placocephalus isabellinus Geba.

(Pl. 4, figs. 1, 2.—Text-fig. 2.)

Placocephalus isabellinus Geba (11), pp. 385, 386.

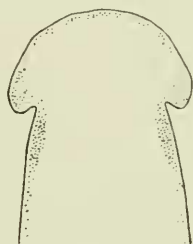
Three specimens of the species, which I identify with *Placocephalus isabellinus* described by Geba from the Mauritius Island, were collected by Mr. Thomasset under half-rotten logs and rocks in damp places in the same island.

The head in the preserved state is of a semilunar shape and not wider than the trunk, from which it is distinctly marked off by a constriction. The trunk is dorso-ventrally depressed, elongate, and nearly uniformly broad for the most part of its length, though it tapers in the hind parts down to the bluntly pointed end. The sole, scarcely raised above the general level, extends from the neck to the posterior extremity, its width being about a quarter that of the body. The large specimen was 120 mm. long by 4 mm. broad, while the small was 50 mm. long by 3 mm. broad.

As mentioned by Geba, the ground colour of the dorsal surface is an umber brown with five longitudinal black stripes, a median

and two pairs of laterals. The median stripe is very fine, extending from the neck to the posterior extremity, and widening slightly above the pharyngeal region. The inner pair are much the strongest of all, and the outer pair at the edge of the body become indistinct as they approach the hind end; on either side both coalesce at the neck into a black patch. The head is marked with a crescentic black pattern. Ventrally, the worm is similar in coloration to the dorsal surface, with a darker shade at the outer edge and also next to the surface of the sole; this latter is very pale.

TEXT-FIG. 2.



Eyes of *Placocephalus isabellinus* Geba.

The numerous eye-spots are distributed all round the head, and are continued sparsely for a considerable distance along the sides of the body. At the sides of the neck they extend somewhat to the ventral surface and form a patch, as seen in Text-fig. 2.

The mouth-opening, which leads into the peripharyngeal chamber, is placed at some distance in front of the centre of the body. In the specimens examined the pharynx was protruded through the mouth-opening as a creamy frill.

The genital organs were unfortunately yet undeveloped in the individuals examined. Like some other forms, this species may to some extent reproduce asexually by transverse fission, as stated by von Graff. On two occasions the severed hind end presented a concave edge, apparently forming the new tail-end.

Rhynchodemus ceylonicus von Graff.

(Pl. 4, figs. 3, 6-8.—Text-figs. 3, 4.)

Rhynchodemus ceylonicus von Graff (12), pp. 499, Pl. xv, figs. 35-38.—Laidlaw (17), p. 579.

The material was collected by Mr. Snell in the island of Rodrigues. At a glance it appeared to be identical with *Geoplana whartoni* described above, as dealt with by the collector, but a closer examination has revealed the fact that this is not so. After some hesitation I have referred it to von Graff's *Rh. ceylonicus*, which has not been adequately described, as Laidlaw referred a worm from Male Atoll to this species, but with some doubt.

This species appears to be fairly common in this island, as it has been procured in enormous quantities at Grande Montagne and also at Mount Malartic. According to Mr. Snell's statement, it is found under decaying logs, on the bark, under the bark, or in the wood; the nemertean appeared to exist in far greater quantities than the terrestrial planarians, but these often live together in the same place.

External Characters (Pl. 4, fig. 3).—The body in the preserved state is nearly oval in transverse section, elongate, slender, and for the greater part of a uniform width, though it gradually tapers off towards the anterior and posterior ends, which are bluntly pointed. The ventral surface is made up of the median somewhat raised sole, on which the animal creeps. It extends over almost the whole length of the body and is rather less than one-fourth the width of the body. This species is wholly devoid of any trace of a sensory pit at the anterior tip. In length the animals range from 22 mm. to 45 mm.; the difference in length depending upon the state of contraction. The 45 mm. specimen was not less than 3 mm. across.

Von Graff is speaking of the coloration of the body as a whole when he states in his description: 'Die Grundfarbe ist lebhaft gelb (sulphureo-citrinus) und der Rücken mit drei sehr kräftigen schwarzbraunen Streifen versehen, von welchen aber die beiden

lateralen mehr als doppelt so breit sind als der mediane. Hinten convergiren die feiner werdenden Längsstreifen, ohne aber zusammenzufliessen, vorne verschwinden sie in der graubraunen Pigmentirung des nur an der äussersten Spitze farblosen Vorderendes. Eine gleiche Trübung findet sich auch auf der Bauchseite des Vorderkörpers. Sie verschwindet erst gegen die Mitte der Körperlänge und erstreckt sich vom Aussenrande der Seitenstreifen des Rückens bis an die Kriechleiste, in deren Umgebung sie am dunkelsten wird.'

In the specimen I have examined, the dorsal surface is of a uniform orange colour with a slight touch of grey and marked with three fine black longitudinal stripes, comprised of one

TEXT-FIG. 3.



Eyes of *Rhynchodemus ceylonicus* von Graff.

median and two lateral, these latter converging towards the extremities of the body and meeting the median one. At the anterior end the lines thicken and then coalesce, revealing a dark tip unlike von Graff's form, in which the anterior tip is light. In most instances the lateral lines are much thicker than the median. Sometimes the former get slightly lighter and are less strongly marked than the latter. The ventral surface is much paler than the dorsal, except on the sole, where the colour is nearly white.

The eyes, which are only two in number, occur on either side near the anterior tip of the body.

The mouth-opening which leads into the peripharyngeal chamber lies nearly in the middle of the body, differing from von Graff's form, in which it is situated at the commencement of the posterior fifth of the body. The pharynx in the normal condition is usually completely retracted and hidden within the

peripharyngeal chamber. In some preserved specimens, it was protruded through the mouth-opening as a cylindrical organ of a creamy or white colour.

The common genital aperture is situated about half-way between the mouth-opening and the posterior extremity of the body.

Epidermis.—The specimens had not been preserved in a condition satisfactory for the purpose of minute examination. The epidermis is not of the same thickness all over the body, being thickest on the dorsal surface, gradually becoming thinner as it passes round to the mid-ventral surface. The cilia, though stated by some investigators to exist over the entire surface of the body, in this species are present on the surface of the sole only. Dorsally and laterally the epidermis, as is well known, is made up of closely packed, elongated, columnar cells resting upon a basement membrane, each with an oval nucleus at its base. Apparently wedged in between these cells, except those that are on the head-surface, are found spindle-shaped bodies, the rhabdites, which originate from their mother-cells, scattered in fair abundance in the parenchyma beneath the dermal musculature. In some cases the rhabdites are seen to be in connexion with their mother-cells. Also there are some unicellular glands which open to the exterior here and there. Between the epidermal cells are found some 'gland cells' with granular contents. These, though having been regarded by Dendy (9) as masses of hardened mucus originating from the rhabdite-forming cells, appear to me to be masses of mucus derived from the glandular cells. Except on the surface of the sole the epidermis on the ventral surface is constructed in the same manner as that on the dorsal. Embedded in the parenchyma are unicellular glands, which are much more abundant on the ventral than on the dorsal surface, and these make their way to the surface generally, instead of opening on the ventral surface, more especially submarginally, as they do in some other terrestrial forms as well as in all the freshwater and marine Triclad. The epidermis on the surface of the sole, as has been already indicated, is composed of closely packed,

short, columnar cells, each bearing a large number of short cilia on its outer surface. In no cases have I been able to demonstrate rod-like bodies, wedged in between the cells. Deeply situated in the parenchyma there are enormous quantities of slime glands, which open to the exterior all over the surface of the sole.

Basement Membrane.—The basement membrane, which is in connexion with the epidermis, is distinctly visible as a very thin, structureless, homogeneous layer. It is perforated at various points by the passages of the rhabdite-forming cells and the glands which lie deep down in the parenchyma.

Muscular System.—The musculature of the body, as is well known, is differentiated into two systems, superficial and deep.

The superficial muscular system consists, as usual, of circular, transverse, and longitudinal fibres. Immediately beneath the basement membrane is a thin muscular layer made up of closely apposed circular fibres. The transverse fibres, crossing those of the other set obliquely, are just inside the circular layer. The longitudinal fibres form a thick layer, the external longitudinal layer, which is more strongly developed on the ventral surface than on the dorsal. The muscles appear separated into a series of bands, each made up of a few fibres. Through the intervals between the bands the rhabdites and the glands make their way to the surface.

The deep muscular system, separated from the superficial by a zone of tissue, forms a layer thicker than the latter, and consists principally of two distinct sets of fibres, longitudinal and circular, which occur intermingled in the same mass, without being arranged in definite layers. The longitudinal fibres are more strongly developed than the circular. In addition to these dorso-ventral muscles are found, which run between the branches of the intestine.

Parenchyma.—The tissue filling all the interspaces between the various organs and structures assumes, as usual, the appearance of an irregular network, in the ground substance of which is found a number of nucleated cells of a more or less stellate shape. Embedded in the superficial parts of the dorsal

parenchyma are the fine pigment granules in enormous quantities, which are of an irregular outline and of a dirty olive-like colour. The pigments, though rather few, occur on the ventral side also.

Body-glands.—Situated in the intervening zone between the superficial and deep muscular systems are two distinct kinds of glands, the mother-cells of the rhabdites and the unicellular glands, as already mentioned. On some occasions the mother-cells of the rhabdites have a very stout, horny-looking cell-wall with a greatly elongated narrow tube tapering off into a long process, each of which makes its way between the epidermal cells at various points. Due to the action of reagents, the cells vary in appearance. In some cases there occur such rhabdites as are still contained in the mother-cells.

The rhabdites vary in form and appearance. Some present a slender spindle-like shape, while others are nearly oval in shape. In no cases have I been able to demonstrate the vermiform bodies which were described by Dendy and others. Sometimes the rhabdites appear almost homogeneous, and sometimes finely granular, but I have no doubt that they are all one and the same thing. In some sections the dorsal surface of the worm, outside the epidermic cells, is seen to be partly covered with a layer of hardened mucus which reveals a character quite similar to the rhabdites. They may possibly, by making the animal extremely unpalatable, serve as a protection for its own body, and also help to hold its prey more securely.

Scattered in sparse numbers in the parenchyma are unicellular glands, which have the finely granular contents and open to the exterior at various points of the body-surface, as mentioned above.

Besides those glands there are slime glands which occur deeply embedded in the parenchyma along the median plane of the body and open out on the surface of the sole. They occur in enormous quantities, and are distinguished from the glands opening out over the whole surface of the body by a closer affinity for borax carmine. In the terrestrial planarians the movements are effected by the action of cilia in mucus which is

constantly being secreted in greater or less quantities, and gives rise to a thin layer between the ventral surface of the body and the substratum. In this case rhythmical wavy motions of the muscles stand, of course, in intimate relation to the movements.

Digestive System.—The mouth-opening, which lies nearly in the centre of the body, leads, as usual, into the wide peripharyngeal cavity with the pharynx horizontally disposed. The cavity is lined with a single layer of epithelial cells made up of pear-shaped cells of a glandular nature, as has been stated by Dendy in *G. spenceri*. The epithelium rests upon a fine basement membrane, beneath which are two layers of circular and longitudinal muscular fibres. Situated in the parenchyma around the cavity are unicellular glands which open into the cavity.

The pharynx is a short, tubular body of a cylindrical shape, which arises from the dorso-anterior wall of the peripharyngeal cavity, with its free end posteriorly directed. The outermost layer of the wall is represented by a very thin, richly ciliated epithelium, immediately beneath which come, as usual, two thin layers of external longitudinal and internal circular muscles. The circular layer is followed, after an interval in which glandular and nervous tissues exist, by a very thick layer of longitudinal muscular fibres. Just external to this layer comes a layer of circular fibres, immediately surrounding the lumen of the pharynx, which is lined by a single layer of non-ciliated cells. Besides the muscles mentioned above, there are found a number of radial fibres, running from the inner circular layer towards the outside.

The lumen of the pharynx leads anteriorly into the intestinal canal, which is of the triclad type. The anterior trunk extends to a point above the brain and usually gives off on each side numerous lateral branches, which are sometimes bifurcated and sometimes trifurcated. The posterior trunks proceed backwards nearly to the hind end of the body, one on each side of the middle line, and are provided with numerous outwardly directed, subdivided branches. The wall of the intestine is a single epithelium made up of high cylindrical cells, which are

placed very closely together and rest on the surrounding tissue. The cells, each with an oval nucleus in its basal portion, contain a great number of coarse, highly refractive granules in the finely granular protoplasm. In some cases the cells were observed to be vacuolated in the distal portion of the cell. So far as I have observed, any special glandular cells are altogether absent in the epithelium.

Nervous System.—The brain is a bilobed organ, situated at the anterior end of the body between the ventral wall and the anterior termination of the intestinal canal. From the brain-mass arise numerous nerves which are distributed over the various parts of the anterior end of the body. But their arrangements were not clearly made out. Each half of the organ is formed of a very finely granular ground-substance, in which small nerve cells occur much more abundantly towards the periphery than in the central part. At various points the mass is perforated by fine muscular fibres in the dorso-ventral direction.

Each half of the brain-mass is continuous posteriorly with one of the longitudinal nerve cords, which proceed straight backwards, until finally they join together at the posterior end of the body. The cords themselves are very thick and usually present, in cross-section, the characteristic spongy or finely reticulate appearance. Small nerve cells are scattered in sparse numbers in the substance of the cords. Throughout their entire course the longitudinal nerve cords are connected by very numerous transverse commissures. Laterally they give off numerous branches towards the nerve plexus, which lies beneath the outer longitudinal muscles of the body and extends completely round the body. The plexus consists of a close network of fine fibres.

Eyes (Pl. 4, fig. 6).—The only special sense-organs which I have seen in the present species are the eyes. Each consists, as usual, of a pigment cup and of numerous visual rods. The pigment cup is of a bell-like shape with its opening directed outwards and upwards, and is as usual formed of very minute, closely packed, spherical granules, of a dark-brown colour.

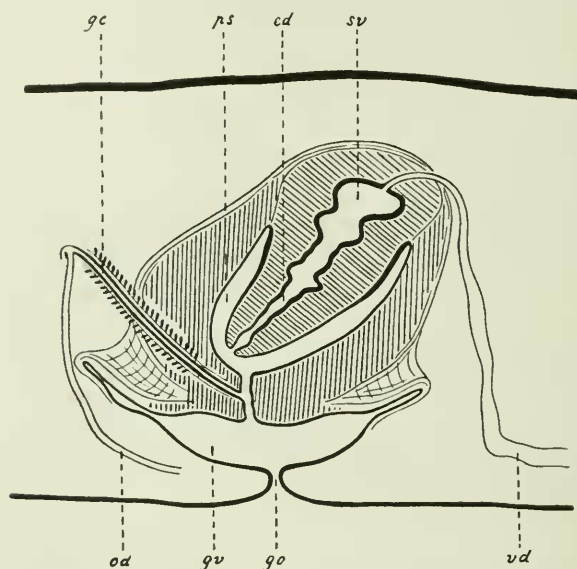
Enclosed in the cup is a mass of visual rods, the outer extremity of which projects for a short distance beyond the margin of the pigment cup. Between the pigment cup and the mass of the visual rods, and also just in front of the outer surface of the rods, small spaces are visible, doubtless caused by shrinkage of the tissues. Each rod is an elongated, faintly staining, very finely granular body, which at the periphery shows a closer affinity for borax carmine than in the central part. In front of the opening is a collection of nervous matter, viz. granular substance and fibres surrounded by numerous cells, apparently belonging to nerve cells. The fibres pass over into the cavity of the pigment cup, but how the nerves stand in connexion with the visual rods I was unable to determine.

Reproductive Organs (Pl. 4, figs. 7, 8).—The common genital aperture, lying nearly mid-way between the mouth-opening and the posterior extremity of the body, leads into the wide, annularly outbulged vestibulum, which receives the opening of the penis-sheath from above. Both the vestibulum and the penis-sheath are lined with a single epithelium resting upon a fine basement membrane, beneath which are found circular and longitudinal muscular layers. Especially around the penis-sheath the muscular layer presents a thick, compact mass, which chiefly consists of circular fibres and is continuous with that of the penis. In the diaphragmatic part between both the cavities just mentioned the radial muscular fibres are present in a strongly developed condition.

Male Organs.—Numerous follicular testes are placed close together in the ventral parts of the body, arranged in a single row on either side of the anterior main gut trunk, just on the dorso-lateral side of the longitudinal nerve cord. The row begins on each side slightly behind the ovary, and extends backwards nearly to the insertion of the pharynx. Each testis, of an oval shape, is made up of sperm-mother-cells and spermatozoa in all stages of development, surrounded by the tunica propria. In contact with the epithelium accumulations of the mother-cells occur, which contain very large, deeply staining, highly granular nuclei. In the cavity of the testis, and separated

from the accumulations of the mother-cells lie some compact masses of metamorphosing spermatozoa. The spermatoblast in a further stage of development presents an elongated, pear-shaped protoplasmic body, in the broad end of which the nucleus is visible as a distinct, deeply staining spot. It is then changed into a spermatozoon, the nucleus forming the head and

TEXT-FIG. 4.



Diagrammatic representation of the genital organs of *Rh. ceylonicus* von Graff. *gv.* = genital vestibulum. Other letters as in Text-fig. 1.

the protoplasm having greatly stretched out and elongated itself into a thin thread to form the tail of the spermatozoon.

Each testis gives rise, on its lower side, to a short canal which communicates soon with the vas deferens. The vasa deferentia, proceeding backwards close along the dorsal sides of the longitudinal nerve cords, rise obliquely upwards to enter, each separately, the bulbous part of the penis at the upper lateral sides, and finally open into the lumen of the penis or the seminal vesicle. The vas deferens, which is filled with spermatozoa, is

lined by a thin, flattened epithelium of nucleated cells resting upon a basement membrane.

The penis consists of two parts, viz. the free, conical intermittent part lying subvertically in the penis-sheath, and the bulbous basal part of muscular nature. Enclosed in the latter part is a wide cavity of somewhat irregular contour, the seminal vesicle, into the anterior extremity of which open the vasa deferentia; posteriorly this is continuous with the ejaculatory duct which opens into the penis-sheath at the tip of the penis. The cavity is lined by a layer of columnar glandular cells, beneath which is a circular muscular layer. Embedded in the parenchyma of the penis are numerous glands which open into the seminal vesicle and the ejaculatory duct. Externally the penis is covered with a thin epithelium which becomes thicker towards the proximal portion, and at the same time is provided with cilia. The epithelium surrounds a muscular layer consisting of external, thick, circular, and internal, thin, longitudinal fibres. On some occasions the penis at the proximal parts gives rise to special processes which are covered with an epithelium made up of ciliated, columnar cells.

Female Organs.—The paired ovary is situated far behind the brain, one on either side close to the dorso-lateral side of the longitudinal nerve cord. Each ovary is nearly oval in shape, and its cavity is lined with a thin epithelium, composed apparently of a single layer of flattened cells. In the interior of the ovary, ova in various stages of development are met with. Occupying the periphery of the ovary occur numerous young ova, each with an oval, large, and highly granular nucleus. In the successive stages of development the ovum assumes a nearly spindle-like shape, as has been mentioned by Dendy. The large nucleus sometimes shows a very distinct chromatin network. Situated in the central and lower regions of the ovary are the ripe ova, which present a round shape and enclose a very large nucleus, revealing a transparent, vesicular aspect.

The vitelline glands are represented by irregularly ramified masses of cells, which are extensively distributed in the interstices between the diverticulæ of the intestinal trunk and stand

at many points in connexion with the oviduct. The vitelline glands consist of large round cells closely packed, each of which contains a highly granular nucleus and highly refractive protoplasmic bodies. Probably, at the time when the ova are passing down, the cells break down and make their way into the oviduct. They are considered to take part in connexion with the nutrition of the ova and also with the formation of the cocoon capsule.

The oviduct arises from the mid-ventral aspect of the ovary as a wide passage; this soon assumes the character of a narrow canal, which proceeds straight backwards, just along the outside of the nerve cord. In the region of the genital opening the oviduct nears the median line, rising upwards at the same time, and finally unites with its fellow of the opposite side, at a point behind the penis, to form the rather wide glandular canal. The oviduct shows a distinct lumen along its entire length. Its actual wall is made up of a layer of distinctly nucleated columnar cells, with well-developed cilia projecting into the lumen of the oviduct. Immediately external to the layer mentioned comes a layer of circular muscular fibres.

As already indicated, the oviduct receives the vitelline glands at several points of its course. The mode of connexion seems nearly similar to that described by Moseley (22), Dendy, von Graff, and others, in several forms. The glands stand in communication with the oviducts by means of the short branches of the latter, which are situated at tolerably regular intervals.

The glandular canal, mentioned above, runs anteriorly and obliquely downwards to open from behind into the atrial passage, between the penis-sheath and the vestibulum. The canal is constructed in the same manner as the oviduct, and is lined with an epithelium made up of ciliated columnar cells resting upon a fine basement membrane, beneath which exists a muscular layer composed of circular and longitudinal fibres. Numerous glands are found all round the canal, into which they open.

The present species is wholly devoid of any trace of the organ representing the seminal receptacle. As already indicated, the

vestibulum is supplied with an annular outbulging, which extends more deeply backwards than forwards. To me, this outbulging appears to serve as a seminal receptacle during copulation.

Amblyplana trifuscolineata, n. sp.

(Pl. 4, figs. 4, 5.—Text-figs. 5, 6.)

This new species is represented by a single specimen which was taken by Mr. Thomasset under a half-rotten log in the island of Mauritius.

External Characters (Pl. 4, figs. 4, 5).—The body, which is nearly circular in cross-section, is rounded at the posterior end, and has the lateral margins even and nearly parallel for a large part of its length, but tapering in front to the bluntly pointed extremity. The sole corresponds nearly to one-third the width of the body, extending to both extremities. It measures 25 mm. long by about 3 mm. across in the broadest part.

In coloration this species nearly resembles Geba's *Amblyplana tristriata*, described by that author from the Comoro Island. The dorsal surface is of a dark colour with a touch of olive-like brown, and marked with three longitudinal black stripes, a median and a pair of laterals, the latter converging towards the extremities of the body, without coalescing. Ventrally, the colour is similar to that of the dorsal side, except for the creeping surface which is pale, while each side of it has a diffused brownish black tinge.

Near the anterior tip of the body lie the eyes, one on each side, as shown in Text-fig. 5.

The mouth-opening, which leads into the peripharyngeal chamber, is situated at a short distance behind the centre of the body. I could make out its position by a slight protrusion of the pharynx.

The common genital opening lies at the hind end of the first third of the distance from the mouth-opening to the posterior extremity of the body.

Epidermis and Body-glands.—The epidermis consists, as usual, of a layer of columnar cells, which are of a greater height on the dorsal than on the ventral side. Wedged in between these cells, except on the ventral surface, are spindle-like rhabdites which appear almost homogeneous. In some sections they are seen to be discharged on to the exterior, revealing a layer of hardened mucus over the epidermis. The rhabdites enclosed in the subcutaneous cells occur widely

TEXT-FIG. 5.

Eyes of *Amblyplana trifuscolineata*, n. sp.

distributed on the dorsal side of the body. In addition to the glands deeply situated in the middle of the body and opening to the exterior on the surface of the sole, there are some glands which open in scattered distribution all over the ventral surface.

Muscular System.—Immediately beneath the fairly well-developed basement membrane is the superficial muscular system composed of the outer circular and the inner longitudinal layers. The deep muscular system, which chiefly consists of longitudinal fibres, is well developed all round in the parenchyma as a thick and continuous sheet surrounding the intestine and the nerve cords.

Digestive System.—The mouth-opening is placed at about the centre of the peripharyngeal chamber, in which is disposed the pharynx of a cylindrical shape. It is conically pointed at the free end. The gut trunks are provided with numerous subdivided branches, the epithelium of which presents no noteworthy features, consisting, as it does, of high columnar cells.

Reproductive Organs.—The genital apparatus is nearly similar in appearance to that of *Am. tristriata* Geba. The genital opening leads into the vestibulum, which forms an

oblique upwardly directed, annular outbulging, and which receives the penis-sheath from above. The vestibulum has a wall consisting of a single epithelium and a muscular layer, while the penis-sheath is lined with a ciliated epithelium, outside which is a thick muscular coating, chiefly composed of circular fibres.

Male Organs.—The numerous testes, containing spermatozoa in several stages of development, are arranged in a row on each side of the body close to the upper side of the longitudinal nerve cords, extending from behind the ovary to the insertion of the pharynx. The vasa deferentia run backwards, just along the inside of the nerve cords. Shortly in front of the penis they gradually bend inwards and upwards, finally to open as a rule separately into a moderately wide seminal vesicle. The vas deferens shows a definite wall consisting of a thin epithelium and a feeble muscular layer of circular fibres.

The penis is a conical body, hanging from above subvertically in the pear-shaped penis-sheath, and encloses a cavity, the seminal vesicle, which gives rise to the ejaculatory duct, opening into the sheath at the tip of the penis. The vesicle is coated internally with a thick glandular epithelium, which projects into the lumen of the organ in folds. Embedded in the body-parenchyma around the penis-bulb are numerous glands, the ducts of which enter the penis at the base and open into the penis-sheath over the surface of it.

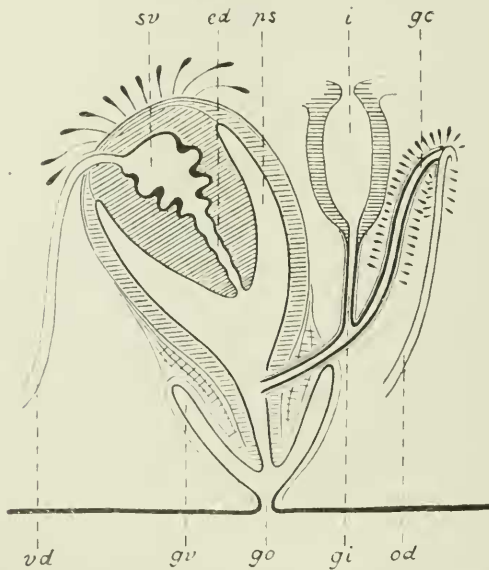
Female Organs.—I am unable to give an account of the ovary, as I have been reluctant to sacrifice the anterior half of the body to the microtome. Probably the paired ovary occurs in the usual manner. The vitelline glands, which are composed of large cells closely packed, extensively fill up the interstices between the gut diverticulae. They are in connexion with the oviduct at numerous points by means of a short cylindrical duct.

The oviducts lie close to the dorso-lateral side of the nerve cords, one on each side, in which position they proceed straight backwards, receiving the contents of many vitelline glands. Behind the genital opening they near the median line, slightly

rising at the same time, and finally join into a single median duct, the glandular canal. The oviduct is characterized by the possession of ciliated epithelial cells, beneath which comes a thin muscular coating, and between which open numerous glands for some little distance before forming a common duct.

The glandular canal pursues a course obliquely forwards and downwards, and finally opens into the vestibulum at a point on the right side, after receiving in its course a short duct from

TEXT-FIG. 6.



Genital organs of *Am. trifuscolineata* in sagittal section, diagrammatically shown. *gi.* = genito-intestinal canal. *i.* = intestine. Other letters as in Text-figs. 1 and 4.

above, which stands in communication with one of the intestinal coeca, so that there is, as in the Heterocotylean Trematodes, a genito-intestinal canal. This is similar to that described by Geba (11) in *Am. tristriata* and *Am. mediotriata*. The canals are constructed in the same manner as the oviduct, and are lined with an epithelium composed of ciliated columnar cells; outside this is a thin muscular layer.

The intestinal coecum is coated internally with an epithelium made up, as usual, of high columnar cells, which near the junction point of the canal exhibit a close affinity for borax carmine ; in the cavity are contained spermatozoa enveloped in a coagulum of the secretion. This organ seems to me to serve as a seminal receptacle.

As stated above, the present species closely resembles *A. m. tristriata* described by Geba. But it differs from this in the arrangement of the parts of the genital organ.

NOTE UPON THE CANAL CONNECTING THE FEMALE GENITAL ORGAN WITH THE INTESTINE.

The peculiar canal connecting the female genital organ with the intestine is of somewhat frequent occurrence in other terrestrial planarians, as is the case with *Rhynchodemus terrestris* Müll., *Rh. attemsi* Bendl, *Pelmatoplanea mahéensis* von Graff, and *P. braueri* von Graff. In *Rh. terrestris*, according to von Graff (12), the two ducts, one on each side, spring from the anterior parts of the seminal receptacle and take a course obliquely upwards and backwards, finally opening into the posterior trunk of either side. But these connexions appear to be inconstant in occurrence and arrangement, for on some occasions there exists, according to Bendl (2, 3, 5), a right connexion only, which is well developed. He has also placed on record a case of *Rh. attemsi*, in which the receptacle is in direct connexion with the left posterior trunk of the intestine, without passing by any distinct duct. According to Mell (20), the vagina in both *P. mahéensis* and *P. braueri* is continuous with a canal which communicates with the right posterior trunk of the intestine.

An arrangement of this kind is also known to occur in other Turbellarian groups. Such are Oersted's *Phaenocora unipunctata*, an Acoela (4, 5), and Haswell's *Enterogonia pigra*, a Polyclad (13, 14). In the former the receptacle communicates with the intestine by a short median duct, while in the latter the dorsal passage of the vagina, after receiving on

its ventral side the common duct formed by union of the lateral uterine ducts, proceeds backwards as a narrow tube, which opens into the median posterior branch of the intestine. To me, such frequent occurrence of the genito-intestinal connexion appears in favour of the view that this is certainly not abnormal. The discovery of the canal in question helps to connect more definitely the seminal receptacle of some Polyclads and Triclad with parts that occur in other Platyodes. It cannot well be doubted, it seems to me, that this canal corresponds to the similarly named canal in the Heterocotylean Trematodes. In this group the duct passes from the oviduct, opposite the opening of the yolk-duct, to the right limb of the intestine.

Now let us proceed to review the arrangement of the terminal part of the female genital organ, which is of interest from the morphological point of view. The vaginal canal, after almost invariably receiving the unpaired common uterine duct, either ends blindly, as in *Stylochus* and some others, or proceeds backwards to join the seminal receptacle, as in some Triclad, which is unpaired in most, but paired in some, genera (*Discoceles*, *Woodworthia*, *Shelfordia*, and *Diplosolenia*). This agrees closely with the condition of the duct found in the Aspidocotylean Trematodes, which are provided with a duct, arising from the oviduct, near or opposite the opening of the yolk-duct and leading to the vitelline receptacle.

On some occasions the dorsal passage of the vagina, instead of swelling into a receptacle and opening into one of the intestinal coeca, pursues a course backwards, finally to open to the exterior at a certain point of the surface of the body. In *Cryptophallus* and *Bergendalia* it proceeds backwards and downwards, describing an arched course, and finally opens into the female atrium closely behind the vaginal aperture and just inside the external female aperture. In the case of *Trigonoporus*, *Copidoplana*, and *Tripyloceles* the duct terminates behind on the ventral surface of the body by the second female aperture. In *Polyporus* the second female opening lies near the hind end of the body, while in *Laidlawia* it occurs, occupying a position on the dorsal, but not on the

ventral, surface. Such an opening dorsally situated is also known to occur in Acoelean forms, such as *Cylindrostoma quadrioculatum* Jens, and *C. klostermanni* Jens.

The discovery of *Laidlawia* (15) mentioned above may be regarded as of some importance, as it may constitute an additional link in the chain of evidence against the homology of the part of the duct, as has been suggested by Lang (18). He, in his monograph, has the following passage: 'In morphologischer Beziehung erinnert der Canal, insofern er eine Verbindung zwischen der Einmündungsstelle des Uterus in den Eiergang einerseits und der Aussenwelt anderseits darstellt, einigermassen an den Laurerschen Canal der Trematoden und Cestoden.' A comparison with the Laurer's canal of the Malacocotylean Trematodes, which passes up from the oviduct, in the neighbourhood of the ootype, and opens by a minute pore on the dorsal surface, obviously suggests itself.

Great interest is attached to the existence of some Polyclads having the dorsal passage of the vagina, which opens either to the exterior on the surface of the body, or into one of the intestinal coeca, as stated above. The homology between the genito-intestinal canal of the Heterocotylea, the Laurer's canal of the Malacocotylea, and the duct leading to the receptacle in the Aspidocotylea, though it may be open to question, seems to have the balance of evidence in its favour. Haswell (14) has put forward the view that there can be regarded as representing Laurer's canal in the Polyclads not only the genito-intestinal canal of *Enterogonia*, but the seminal receptacle of the Acotylea in general and the posterior female passage, which opens to the exterior, as has been observed in some forms. I am inclined not only to concur with him, but further to develop to a certain extent this view even to the Triclad. In this communication, however, I have intentionally abstained from making any such attempt, leaving the problem to future consideration.

REFERENCES.

1. Balfour, J. B., and others. 1878. "An Account of the Petrological, Botanical, and Zoological Collections made in Rodrigues during the Transit of Venus Expeditions in 1874-5", 'Phil. Trans. Roy. Soc.', vol. clxviii (extra volume), pp. 561, 562.
2. Bendl, W. E., 1908. "Beiträge zur Kenntnis des Genus *Rhynchodemus*", 'Zeitschr. f. wiss. Zool.', Bd. lxxxix.
3. — 1909. "Europäische Rhynchodemiden, i", 'ibid.', Bd. xcii.
4. — 1909. "Rhabdocöle Turbellarien aus Innerasien", 'Mitth. d. Naturwiss. Ver. f. Steiermark', Bd. xlv.
5. — 1909. "Der Ductus genito-intestinalis der Platheminthen", 'Zool. Anz.', Bd. xxxiv.
6. Bock, Sixten, 1913. "Studien über Polycladen", 'Zoologiska Bidrag f. Upsala', Bd. ii.
7. Böhmig, L., 1890. "Untersuchungen über rhabdocöle Turbellarien, ii, Plagiostomia und Cyliodrostomia v. Graff", 'Zeitschr. f. wiss. Zool.', Bd. li.
8. Busson, B., 1903. "Ueber einige Landplanarien", 'Sitzungsber. Akad. Wien', vol. cxii, pp. 375-429.
9. Dendy, A., 1889. "The Anatomy of an Austrarian Landplanarian", 'Trans. Roy. Soc. Victoria', vol. i, part 2.
10. Fuhrmann, O., 1912. "Voyage d'exploration scientifique en Colombie. Planaires terrestres de Colombie", 'Mém. Soc. neuchâtoise sc. nat.', vol. v, pp. 748-92.
11. Geba, J., 1909. "Landplanarien von Madagaskar und den Comoren", 'Voeltzkow, Reise in Ostafrika in den Jahren 1903-1905. Wissenschaftliche Ergebnisse', Bd. ii.
12. Graff, L. von, 1899. "Monographie der Turbellarien. ii. Triclada Terricola (Landplanarien)."
13. Haswell, W. A., 1907. "A genito-intestinal canal in Polyclads", 'Zool. Anz.', Bd. xxxi.
14. — 1907. "Observation on Australian Polyclads", 'Trans. Linn. Soc., London', 2nd ser., vol. ix.
15. Herzig, E. M., 1905. "*Laidlawia trigonopora*, n. gen., n. sp.", 'Zool. Anz.', Bd. xxix.
16. Ikeda, I., 1911. "Note on a new Land Planarian from Ceylon", 'Spolia Zeylonica', vol. vii, part xxvii.
17. Laidlaw, F. F., 1903. "On a Land Planarian from Hurule, Male Atoll, with a note on *Leptoplana pardalis* Laidlaw", 'Fauna and Geogr. Maldive Laccadive Archip.', vol. ii, part i, p. 579.
18. Lang, A., 1884. "Die Polycladen", 'Fauna u. Flora des Golfes von Neapel'. xi. Monographie.

19. Meixner, A., 1906. "Zwei neue Landplanarien", 'Zool. Anz.', Bd. xxix, p. 665.
20. Mell, C., 1903. "Landplanarien der Madagassischen Subregion", 'Abhandl. d. Senkenb. naturf. Ges. Frankfurt', Bd. xxvii.
21. — 1904. "Die von Oscar Neumann in Nordost-Afrika gesammelten Land-Planarien", 'Zool. Jahrb., Abt. Syst.', Bd. xx.
22. Moseley, H. N., 1875. "On the Anatomy and Histology of the Land-planarians of Ceylon, &c.", 'Phil. Trans. Roy. Soc.', vol. clxiv.
23. Scharff, R. F., 1900. "Rhynchodemus Howesi: a new European Species of Terrestrial Planarian Worm", 'Journ. Linn. Soc.', vol. xxviii.
24. Snell, H. J., and Tams, W. H. J., 1920. "The Natural History of the Island of Rodrigues", 'Proc. Cambridge Phil. Soc.', vol. xix, part 6, p. 287.
25. Whitehouse, R. H., 1914. "Land Planarians", 'Rec. Indian Mus.', vol. viii, part 6.
26. — 1919. "Indian Land Planarians", *ibid.*, vol. xvi, part 1.

EXPLANATION OF PLATE 4.

Fig. 1.—*Placocephalus isabellinus* Geba in the preserved state, seen from the dorsal side. About natural size.

Fig. 2.—Ditto. Ventral view.

Fig. 3.—*Rhynchodemus ceylonicus* von Graff in the preserved state, seen from the dorsal side. About 1.5 ×.

Fig. 4.—*Amblyplana trifuscolineata*, n. sp. in the preserved state, seen from the dorsal side. About 2 ×.

Fig. 5.—Ditto. Ventral aspect.

Fig. 6.—*Rh. ceylonicus*. Longitudinal section of an eye.

Fig. 7.—Ditto. Transverse section through the ovarian region.

Fig. 8.—Ditto. Median sagittal section through the region of the copulatory organs.

ABBREVIATIONS USED IN THE EXPLANATION OF PLATE.

ed. = ejaculatory duct. *gc.* = glandular canal. *gv.* = genital vestibulum. *i.* = intestine. *ln.* = longitudinal nerve cord. *n.* = nerve. *od.* = oviduct. *ov.* = ovary. *p.* = pigment. *ps.* = penis-sheath. *s.* = sole. *sr.* = seminal vesicle. *vd.* = vas deferens. *vr.* = visual rod.